Specification

1. Title of the Invention

Substrate Changing-Over Mechanism in Vacuum Tank

2. What is claimed is:

(1) A substrate changing-over mechanism within a vacuum tank, comprising:

a substrate supporting means arranged within the vacuum tank which has at least two openings at a side wall thereof, the openings being openable or closable by gate valves, said substrate supporting means having at least two stages of substrate supporting sections in upper and lower spaces; and

an ascending or descending driver section for driving said substrate supporting means in such a way that said substrate supporting means can be stopped in a vertical direction at a plurality of predetermined positions;

wherein a substrate of which surface has been processed can be mounted on one of said two stages, and a substrate not processed can be mounted on the other of said two stages.

(2) A substrate changing-over mechanism according to Claim 1, wherein one of said two stages is cooled.

(3) A substrate changing-over mechanism according to

Claim 1, wherein the other of said two stages is heated.

(4) A substrate changing-over mechanism according to Claim 1, wherein one gate valve of said both gate valves for performing communication with atmosphere and for shielding is configured in such a way that an opening, at the vacuum chamber, of through-pass holes arranged at the side wall of said vacuum tank is upwardly inclined, and a valve plate for opening or closing said opening is ascended or descended by a driving source arranged at an atmosphere side through a rod extended through a vacuum partition wall and obliquely drawn out toward atmosphere.

(5) A substrate changing-over mechanism according to Claim 4, wherein said valve plate is formed to be larger than a diameter of the substrate, and connected to a cylinder mounted at the atmosphere side through two rods fixed to both sides of the valve plate and drawn out to atmosphere.

3. Detailed Description of the Invention

[Industrial Field of the Invention]

This invention relates to a substrate changing-over mechanism in a vacuum tank.

[Prior Art and Its Technical Problem]

Fig. 11 shows one example of the prior art loading mechanism for taking a wafer from atmosphere into a vacuum tank. In this figure, this mechanism has a function in

which it is operated such that a wafer (106) fed into a vacuum tank (101) from the atmosphere into the vacuum tank (101) through a gate valve or a gate valve (104) by means such as a belt conveyer (109) is taken into an appropriate position within the tank (101) by a belt conveyer (102) arranged in the vacuum tank (101), this wafer is lifted up from the belt position by a wafer moving-up or -down mechanism separately arranged and then it is loaded onto another mechanism disposed below the wafer (106).

Now, the above-mentioned operation will be described in detail as follows. That is, as shown in Fig. 11A, the wafer (106) having its surface to be processed which is passed through the gate valve (104) from the atmosphere and fed into the vacuum tank (101) is further transferred up to an appropriate position by a belt conveyer (102) arranged within the vacuum tank (101) and stops there. Then, the gate valve (104) is closed and the inside of the vacuum tank (101) is evacuated into a vacuum state.

As shown in Fig. 11B, at the aforesaid time, a wafer pushing device (108) positioned below a position where the wafer (106) rides on the belt (102) is lifted up by the wafer moving-up or -down cylinder (103) while a vacuum sealing is being kept through a bellows (105) to lift up the wafer (106) more upwardly than the belt surface, and then another wafer transferring mechanism (107) (for

example, a pick-up of a fork transferring device) advances below the wafer (106).

Then, as shown in Fig. 11C, the wafer pushing device (108) descends and the wafer (106) is delivered onto another wafer transferring mechanism (107).

The foregoing relates to an operation in which the wafer (106) is taken into the vacuum tank (101) from the atmosphere, while in turn a procedure in which the processed wafer (106) is taken out to the atmosphere is performed in the order opposite to the former one. That is, in the case of the aforesaid example of the prior art, the wafer (106) already processed is transferred by the mechanism (7) into the vacuum tank (101) evacuated into vacuum, thereafter the vacuum tank (101) is ventilated and the processed wafer (106) is taken out. Further, the wafer (106) not yet processed is taken into the vacuum tank (101) to perform a vacuum evacuation, and thereafter it is transferred to a processing chamber by the mechanism (107). During a loading and an unloading of the wafer including the aforesaid evacuation cycle between atmosphere and vacuum, the processing chamber requires a waiting time, resulting in that its efficiency is poor.

In order to avoid this problem, although there is used a method in which a vacuum tank for loading the wafer and a vacuum tank for unloading the wafer are separately

arranged, this method causes a configuration of the device to be complicated.

In addition, in the case where there is provided only one vacuum tank, a fast evacuation and a fast ventilation are required to make a fast evacuating cycle between atmosphere and vacuum in a normal way although depending on a through-put of the device, a recent trend in which a pattern size of an LSI is made to be fine causes it to be essential that an adhesion of particle to the wafer is restricted as much as possible and so a fast evacuation or fast ventilation within the vacuum tank where a flying of particles may easily be produced is not preferable.

[Problems to be Solved by the Invention]

It is an object of the present invention to provide a substrate changing-over mechanism within a vacuum tank in which various kinds of disadvantages found in the prior art are overcome, a next wafer is loaded into the vacuum tank while the previous loaded wafer (substrate) is being processed in the processing chamber, and further the vacuum evacuation is already completed, whereby time required to perform ventilation and evacuation is omitted from the wafer changing-over work at the processing chamber, and a waiting time at the processing chamber is reduced to improve productivity.

[Means for Solving the Problems]

The aforesaid object is accomplished by a substrate changing-over mechanism within a vacuum tank, comprising: a substrate supporting means arranged within the vacuum tank which has at least two openings at a side wall thereof, the openings being openable or closable by gate valves, said substrate supporting means having at least two stages of substrate supporting sections in upper and lower spaces; and an ascending or descending driver section for driving said substrate supporting means in such a way that said substrate supporting means can be stopped in a vertical direction at a plurality of predetermined positions; wherein a substrate of which surface has been processed can be mounted on one of said two stages, and a substrate not processed can be mounted on the other of said two stages.

[Operation]

A processing in which the substrate already processed is mounted at one of the two upper and lower stages of the substrate supporting sections while the substrate not yet processed is being mounted is carried out under a vacuum state, then the substrate not yet processed is transferred to the required processing chamber under this state, after this operation, an inside part of the vacuum tank is changed into surrounding atmospheric pressure, the substrate not yet processed is transferred to said one substrate supporting section and the substrate

already processed is transferred to the desired location in the atmosphere. Then, the inside of the vacuum tank is evacuated and then the aforesaid operation is repeated.

In the aforesaid series of operation, the operation in which the inside part of the vacuum tank is set to the surrounding atmospheric pressure, the substrate not yet processed is loaded to one substrate supporting section, the substrate already processed is unloaded to the desired location in the atmosphere and further the inside part of the vacuum tank is evacuated is already completed while the substrate not yet processed transferred to the processing chamber is being processed.

[Preferred Embodiment]

Referring now to the drawings, a CVD device according to the preferred embodiment of the present invention will be described as follows.

Fig. 1 schematically shows a device (1) of the present invention, wherein there are provided a pair of right and left CVD reaction chambers (2a), (2b) and a buffer chamber (3) is arranged between these reaction chambers. A partition wall between the buffer chamber (3) and both reaction chambers (2a), (2b) is provided with gate valves (4a), (4b) and then loading or unloading of the wafer is carried out through these members. A wafer changing-over chamber (5) according to the present

invention is arranged in front of the buffer chamber (3) and loading or unloading of the wafer is carried out between these chambers (3), (5) through the gate valve (6).

A wafer transferring mechanism (7) is arranged within the buffer chamber (3). The wafer transferring mechanism (7) is provided with a transferring fork (8), it can be rotated around a central shaft (9) as indicated by an arrow (a) and can be extended or shrunk as indicated by an arrow (b). Both side walls of the wafer changing-over chamber (5) are also provided with gate valves (10), (11), a not processed wafer transferring belt (12) is provided on one side of the gate valves, one piece of wafer is automatically taken out from a wafer stock cassette (13) under a predetermined timing and then the wafer is loaded into the wafer changing-over chamber (5) by the belt (12). In turn, a processed wafer unloading belt (14) is provided on the other side and the wafer is loaded into the processed wafer stock cassette (15).

Then, referring now to Figs. 2 to 9, details of the wafer changing-over chamber (5) will be described.

As shown in Fig. 2, the wafer changing-over chamber (5) is defined by a closing tank (21), and as described above, both side walls are provided with gate valves (10), (11) (not shown in Fig. 2), the rear wall part is provided with a gate valve (8). Details of these gate valves (8),

(10), (11) will be described later. An inside part of the chamber (23) is sealingly closed under these closed state and the inner side of the chamber (23) is kept in vacuum or pressure reduced state by an evacuating mechanism not shown.

Within the chamber(23) is arranged a substrate supporting member (24) of which entire shape is clearly illustrated in Fig. 5, wherein a driving shaft (25) is fixed to the bottom surface of the substrate supporting member 24. The driving shaft 25 air-tightly passes through the bottom wall of the closed tank (21), extends into lower atmosphere and is fixed to a screw engaging member (27). The driving shaft (25) is air-tightly and slidably supported by a vacuum seal (26) in an upward or downward direction.

The screw engaging member (27) is threadably engaged with a ball screw (28), and a pulley (29) is fixed to the lower end of the screw (28). A motor (31) is fixed to a frame (not shown), and a belt (30) is wound and installed between the pulley (32) fixed to the rotating shaft and the aforesaid pulley (29). The ball screw (28) is rotated under rotation of the motor (31), whereby the screw engaging member (27) and the driving shaft (25) are moved in an upward or downward direction. The motor (31) can be freely rotated in a normal or reverse direction, and the driving shaft (25) is moved in an upward or downward

direction in response to this rotating direction. A height sensor device (36) is provided on one side of the screw engaging member (27), each of the height positions of the driving shaft (25) is detected by this sensor and then driving of the motor (31) is controlled by this sensed signal.

The ball screw (28) is made such that as known in the art a ball is fitted into a threaded groove and the driving shaft (25) can be lifted up or descended down accurately to a predetermined position without any backlash.

The screw engaging member (27) is formed with a cooling water inlet and a cooling water outlet port on a small diameter part thereof, and to each of the inlet and outlet ports is connected a cooling water feeding tube (33) and a cooling water feeding-out tube (34), respectively. Within the driving shaft (23) are formed a feeding passage and a discharging passage (not shown) and these passages are communicated with a circulating passage (35) formed in a zig-zag fashion within a base part (37) of the substrate supporting member (24). In addition, the substrate supporting member (24) is made of aluminum and has a superior thermal conductivity.

The gate valves (6), (10), (11) are arranged at three side walls of the closed tank (21) as described above, wherein it is constructed such that openings (6a), (10a),

(11a) formed at these side walls are air-tightly closed, this arrangement is schematically shown in Fig. 1. In Fig. 2, a detail of the gate valve (6) is illustrated.

Referring to Fig. 2, the gate valve (6) will be described at first, wherein this is a widely well-known structure. The gate valve (6) mainly comprises a gate main body (71) for opening or closing the opening (6a), and a driving member (72) connected to the gate main body with parallel links (73), (74), a lower end portion of the member (72) is protruded out to the atmosphere through a vacuum seal (75) and it is driven by a cylinder device (76) in an upward or downward direction. In Fig. 2, the gate main body (71) closes the opening (6a), wherein as the driving member (72) is descended, the gate main body (71) releases the opening (6a) and further as the driving member (73) is ascended, it may close the opening (6a) as shown in Fig. 2.

Next, details of the gate valves (10), (11) will be described as follows. Since the gate valves (10), (11) have the same configurations to each other, only the gate valve (10) will be described as follows in reference to Figs. 3 and 4. Fig. 3 is an essential sectional view for showing an operating state of the gate valve (10). A partition wall C for partitioning an atmospheric space A from a vacuum chamber B (the wafer changing-over chamber

(5) is formed with a through-pass hole (41), an opening (10a), at the vacuum chamber B, of the through-pass hole (41) is formed upwardly obliquely.

A valve plate (43) for opening or closing a valve seat formed around the opening (10a) is arranged in opposition to it. The valve plate (43) is formed to have a larger size than a diameter of the wafer (47) and connected to the hydraulic (hydraulic or pneumatic) driving cylinder (45) arranged below in the atmosphere space A through two rods (44a), (44b) (one of them is shown in Fig. 3) passed through the hole (41) and partition wall C at both sides and extending obliquely downwardly. As shown in Fig. 4, the aforesaid two rods (44a), (44b) are set such that their upper ends are fixed more inside than O-rings (43a) at both sides of the valve plate (43) are, and the rod and the valve plate are sealed with welding (43b) or the like so as not to generate any leakage from their connected portions. In addition, the lower end is connected to a piston rod (44) of a cylinder (45) through a connecting member (44c) connecting two rods. In the figure, reference numerals (45a), (45b) denote pressure fluid supplying or discharging conduits for the cylinder (45), and reference numerals (12), (48) denote transfer belts mounted at each of the surrounding atmospheric space A and the vacuum chamber B, reference numeral (49) denotes a bearing bushing and

reference numeral (50) denotes an O-ring.

Since the gate valves are configured as described above, during a normal state, i.e. when the wafer is not loaded the valve plate (43) sealingly closes the opening (42) at the vacuum chamber side of the through-pass hole (10a) of the partition wall C under a reversed pressure state, i.e. under a state in which a pressure (atmospheric pressure) is acted via the through-pass hole (10a) in a valve opening direction with the hydraulic pressure acting in a downward direction within the cylinder (45). Accordingly, the vacuum state in the vacuum chamber B is not leaked through the through-pass hole (10a).

Then, in the case where the wafer (47) fed from the surrounding atmospheric space A with the transfer belt (12) is transferred to the vacuum chamber B, the fluid passage in the cylinder (45) is changed over to cause the valve plate (43) to be lifted up through rods (44), (44a), (44b) and then the opening (42) is released. At this time, the through-pass hole (10a) is positioned at a middle part between the two rods (44a), (44b), so that no hindrance is produced against a passage of the wafer (47), and then the wafer is smoothly transferred to the vacuum chamber B.

Then, at the stage in which the wafer (47) is completely transferred into the vacuum chamber B, the flow passage in the cylinder (45) is changed over again and the

valve plate (43) is descended, resulting in that the opening (10a) is closed. In addition, the wafer (47) transferred into the vacuum chamber B is transferred by the transfer belt (48) up to a predetermined position of the substrate supporting member (24).

In accordance with the preferred embodiment, the driving source for operating the valve plate is arranged at the atmosphere side and all the sliding sections for use in operating the valve plate are located below the wafer, so that there occurs no possibility at all that dusts generated at the sliding sections drop onto the wafer. The vacuum chamber is not contaminated by the driving source, too. Further, since the valve plate and the rods are arranged while being inclined to the vacuum partition wall, so that they can be formed compact. Further, since both transfer belts for the wafer in both chambers can be arranged to be adjacent to each other, the device becomes compact and correspondingly its workability in operation is also improved. In addition, since the valve plate results in sealing the opening under the reverse pressure state against the pressure difference, it is necessary to select the valve plate having a sufficient rigidity and a cylinder (a driving source) having a sufficient thrust force.

In the aforesaid preferred embodiment, although it has been described about the structure in which the fluid

pressure driving cylinder is used as a driving source for the valve plate, it is of course apparent that the present invention is not limited to this embodiment, and it is also possible to replace it with a mechanical driving mechanism.

Next, referring now to Figs. 5 to 9, details of the substrate supporting member (24) will be described as follows.

A substrate part (37) of the substrate supporting member (24) is formed with a fork receiving recess (51) which is formed at a much lower level than this upper surface is, and a pair of grooves (52a), (52b) are formed in communication with the recess. In Fig. 6 is illustrated a part of the wafer transfer fork (8), and the fork sections (8a), (8b) can be inserted into the grooves (52a), (52b).

A pair of parallel recesses (53a), (53b) are formed over an entire height at a half part of the wafer loading side of the substrate supporting member (24) in a direction perpendicular to an extending direction of the grooves (52a), (52b) and a pair of parallel recesses (54a), (54b) are also formed at the half part of the wafer carrying out side while being aligned with the recesses (53a), (53b). However, as clearly shown in Figs. 6 and 8, one end of it is not covered over the entire height, but covered by the connecting section.

Belt conveyors (56a), (56b), (57a), (57b) are arranged in compliance with the recesses (53a), (53b), (54a), (54b) in a vertical direction and the belt conveyers can pass through the recesses (53a), (53b), (54a), (54b) when the substrate supporting member (24) is moved up and down. The belt conveyors (56a), (56b) entirely constitute the belt conveyor (48) shown in Fig. 3.

At the central upper part of the substrate supporting member (24) are formed a partial flange-shaped upper stage substrate supporting section (58) and a concentric partial circular-shaped lower stage supporting section (59). As clearly shown in Fig. 6, the upper stage substrate supporting section (58) is comprised of arc-shaped receiving surfaces (58a), (58b), (58c), (58d), (58e), (58f) and they are placed on the same level. However, as shown by a dotted line in Figs. 7 and 8, a not processed wafer (47) is mounted on the upper stage substrate supporting section (58) composed of these elements. In addition, the lower stage substrate supporting section (59) comprises receiving surfaces (59a), (59b), (59c), (59d), (59e), (59g) having the same level and constituting a part of circle, wherein as clearly indicated by a dotted line, the wafer (47)' already processed at its surface is mounted on these elements.

Although a circular stepped hole recess (60) is

formed on the bottom surface of the substrate section (37), the upper end of the aforesaid driving shaft (25) is fitted in the recess and fixed with a screw not shown.

The foregoing has been described in reference to the preferred embodiment and its operation will be described as follows.

Figs. 10A to 10F illustrate each of height positions of the substrate supporting member (24) and in accordance with the preferred embodiment, the substrate supporting member (24) can take five kinds of height positions. Both a level of the fork (8) extended out of or shrunk from the buffer chamber (3) and a level of each of the belt conveyors (56a), (56b), (57a), (57b) are kept constant. A shape of the substrate supporting member (24) in Fig. 10 is shown in its simplified form, and the aforesaid upper stage supporting section (58) and the lower stage supporting section (59) for the wafer are shown in the turned U-shaped upper arm and the turned U-shaped lower arm in order to facilitate an illustration of the figure, wherein they are denoted by U or D, respectively. (That is, U and D are equivalent for the upper stage supporting section (58) and the lower stage supporting section (59).) It is now assumed that the substrate supporting member (24) is placed at the height position shown in Fig. 10A and the not processed wafer (47) is mounted on the upper stage

supporting section U. Further, it is assumed that the gate valves (10), (11) at both side walls are closed. (The gate valve (6) is opened and kept under a vacuum state.) Under this state, the fork (8) extends from the buffer chamber (3) to mount the processed wafer (47)' and reaches a location between the upper stage supporting section U and the lower stage supporting section D as shown in Fig. 10A.

In this case, the substrate supporting member (24) ascends to the position shown in Fig. 10B. During this ascending operation, the processed wafer (47)' is mounted on the lower stage supporting section D, and stops there. Although the substrate supporting section (24) ascends and stops at a position shown at a position in Fig. 10B, the fork (8) in this case is apart from the processed wafer (47)' and is kept at the illustrated position (within the grooves (52a), (52b)). At this position, the fork (8) retracts toward the buffer chamber (3) as indicated by an arrow.

As shown in Fig. 10C, the substrate supporting member (24) descends and again occupies the same position as that of the height shown in Fig. 10A. Then, the fork (8) extends from the buffer chamber (3) into the wafer changing-over chamber (5) as indicated by an arrow in Fig. 10C and occupies the position shown in the figure. The substrate supporting member (24) is moved in a downward

direction and occupies the position shown in Fig. 10D. Thus, the not processed wafer (47) is carried by the fork (8). Then, the fork (8) returns back to the buffer chamber (3).

As shown in Fig. 10E, the substrate supporting member (24) is further moved in a downward direction. At this position, the gate valve is closed and the wafer changing-over chamber (5) is returned back the state kept at surrounding atmospheric pressure. Then, the gate valves (10), (11) are opened.

As the substrate supporting member (24) is stopped at the position indicated in Fig. 10B, the processed wafer (47)′ is mounted on the conveyer belts (57a), (57b) as shown in the drawing. In this case, since the gate valves (10), (11) are opened, the processed wafer (47)′ passes through the opening (11a), is transferred by the belt conveyor (14) and fed into a processed wafer cassette (15). The substrate supporting member (24) is further moved in a downward direction, and occupies the location shown in Fig. 10F. At this position, the belt conveyors (12), (56a), (56b) are located more upwardly than the upper stage supporting section U of the substrate supporting member (24). However, the wafer (47) taken out of the wafer stock cassette (13) for not processed wafer in that position is transferred by the belt conveyor (12), passes through an

opening (14a) and is guided into the wafer changing-over chamber (5). Then, the substrate supporting member (24) is moved upwardly, and occupies the position shown in Fig. 10A. That is, the belt conveyors (56a), (56b), (57a), (57b) are positioned below the substrate supporting member (24). The not processed wafer (47) is mounted on the upper stage U. In this case, the gate valves (10), (11) are closed and the inner side of the changing-over chamber (5) is evacuated to a vacuum state. As already described above, the gate valve (6) is opened and then the fork (8) reaches to the position shown in Fig. 10A from the buffer chamber (3) into the buffer changing-over chamber (5) while mounting the processed wafer (47)' on it. After that, the aforesaid operation is repeated as follows.

In the case of the aforesaid steps, when the processed wafer (47)' is mounted at the lower stage supporting section D, cooling water is being circulated within the substrate section (37) of the substrate supporting member (24), so that the processed hot wafer (47)' is cooled through a heat exchanging with the cooling water. With such an arrangement as above, when the wafer is transferred out of the wafer changing-over chamber to the atmosphere, the wafer is scarcely subjected to any chemical change and the wafer can be stored within the cassette (15) under a stable state.

Although the preferred embodiment of the present invention has been described above, it is of course apparent that the present invention is not limited to this embodiment, but various kinds of modification can be carried out in response to a technical concept of the present invention.

For example, in the case of the aforesaid preferred embodiment of the present invention, although the not processed wafer (47) is mounted on the upper stage supporting section (58) and the processed wafer (47)' is mounted on the lower stage supporting section (59), it may also be applicable that the number of steps of these supporting sections is increased, they are classified into two groups, each of the not processed wafers is mounted in one group of the supporting sections and each of the processed wafers is mounted in the other group. Each of the loading or unloading of the processed wafer and the not processed wafer is carried out in a synchronous manner. In this case, although a loading or unloading belt conveyor is required in response to the number of steps, a plurality of forks are required for loading or unloading of the wafer from the buffer chamber to the changing-over chamber or in turn from the changing-over chamber to the buffer chamber, it may also be applicable that these forks are integrally assembled in an upward or downward direction to perform a

synchronous operation.

In addition, although the lower stage for supporting the processed wafer is cooled to cool the processed wafer in the aforesaid preferred embodiment, it is also applicable that a heating means is arranged at the upper stage supporting section in place of it to heat the not processed wafer mounted on the supporting section. It is also applicable that this heated wafer is loaded into the buffer chamber (3) and the reaction chamber (2a), or (2b).

In addition, it may also be applicable that a thermal insulating material is placed between the upper stage supporting section and the lower stage supporting section of the substrate supporting member (24), the upper stage supporting section is provided with a heating means and the lower stage supporting section is provided with a cooling means in the same manner as that found in the aforesaid preferred embodiment.

In the aforesaid preferred embodiment, there are provided five kinds of height position of the substrate supporting member (24), although this number is increased further to perform the loading or unloading of the aforesaid wafer at each of the height positions by another method other than the aforesaid loading and unloading methods for the wafer. In this case, the number of belt conveyors and the forks acting as the loading or unloading

mechanism is not limited to one, but a plurality of conveyors or forks can be arranged. In addition, the loading or unloading means is not limited to the fork or belt conveyor, but various kinds of known means can be applied. In the aforesaid preferred embodiment, although the processed wafer and the not processed wafer are loaded or unloaded separately through a separate gate valve, these operations may be carried out through one common gate valve.

[Effect of the invention]

As described above, in accordance with the substrate changing-over mechanism placed in the vacuum tank of the present invention, it becomes possible to perform an unloading operation for transferring the processed wafer from the wafer changing-over chamber to the predetermined position in the atmosphere, a loading operation for inputting the wafer from the predetermined position in the atmosphere to the wafer changing-over chamber, a ventilating operation and an evacuating operation accompanied with the former unloading or unloading operation in synchronization with another processing of the wafer at the processing chamber, as a result of which a time required for performing the wafer changing-over operation at the processing chamber can be minimized and its productivity can be improved more.

4. Brief Description of the Drawings

Fig. 1 is a top plan view for showing an entire arrangement of a CVD device in accordance with the preferred embodiment of the present invention.

Fig. 2 is a sectional view for showing a substrate changing-over mechanism in the aforesaid device.

Fig. 3 is a sectional view for showing a detail of a gate valve in the substrate changing-over mechanism.

Fig. 4 is a perspective view for showing a part in Fig. 3.

Fig. 5 is an enlarged perspective view for showing a substrate supporting member in the substrate changing-over mechanism.

Fig. 6 is a top plan view of Fig. 5.

Fig. 7 is a sectional view taken along line VII-VII in Fig. 6.

Fig. 8 is a sectional view taken along line VIII-VIII in Fig. 6.

Fig. 9 is a sectional view taken along line IX-IX in Fig. 6.

Figs. 10A to 10F are side elevational views for showing each of substantial portions to indicate an action of the preferred embodiment of the present invention.

Fig. 11 is a sectional view for showing a substrate changing-over mechanism in the prior art.

In the figures:

(5) … wafer changing-over chamber

(6) (10) (11) … gate valve

(21) … substrate supporting member

(58) … substrate upper stage supporting section

(59) … substrate lower stage supporting section

VACUUM PROCESSING APPARATUS AND OPERATING METHOD THEREFOR

This application is a Continuation application of Serial No. 08/882,731, filed June 26, 1997, which is a Divisional application of Serial No. 08/593,870, filed January 30, 1996, which is a Continuing application of Serial No. 08/443,039, filed May 17, 1995, which is a Divisional application of Serial No. 08/302,443, filed September 9, 1994, which is a Continuing application of Serial No. 08/096,256, filed July 26, 1993, which is a Continuing application of Serial No. 07/751,951, filed August 29, 1991.

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to a vacuum processing apparatus and operating method therefor. More specifically, the present invention relates to a vacuum processing apparatus having vacuum processing chambers the inside of which must be cleaned, and its operating method.

Description of the Prior Art

In a vacuum processing apparatus such as a dry etching apparatus, a CVD apparatus or a sputtering apparatus, a predetermined number of substrates to be treated are stored as one unit (which is generally referred to as a "lot") in a substrate cassette and are loaded in the apparatus. The substrates after being processed are likewise stored in the same unit in the substrate cassette and are recovered. This is an ordinary method of operating these apparatuses to improve the productivity.

In such a vacuum processing apparatus described above, particularly in an apparatus which utilizes a reaction by an active gas, as typified by a dry etching apparatus and a CVD apparatus, reaction products adhere to and are deposited on a vacuum processing chamber with the progress of processing. For this reason, problems such as degradation of vacuum performance, the increase of dust, the drop of the levels of optical monitoring signals occur. To solve these problems, conventionally the insides of the vacuum processing chambers are cleaned periodically. Cleaning operations include so-called "wet cleaning" which is wiping-off of the adhering

matters by use of an organic solvent, etc., and so-called "dry cleaning" in which an active gas or plasma is used for decomposing adhering matters. Dry cleaning is superior from the aspect of the working factor and efficiency. These features of the dry cleaning have become essential with the progress in automation of production lines.

An example of vacuum processing apparatuses having such a dry cleaning function is disclosed in Japanese Utility Model Laid-Open No. 127125/1988. This apparatus includes a preliminary vacuum chamber for introducing wafers to be treated into a processing chamber from an atmospheric side to a vacuum side, which is disposed adjacent to the processing chamber through a gate valve, dummy wafers are loaded in the preliminary vacuum chamber and are transferred into the processing chamber by exclusive conveyor means before the processing chamber is subjected to dry cleaning, and the dummy wafer is returned to the vacuum preparatory chamber by the conveyor means after dry cleaning is completed.

SUMMARY OF THE INVENTION

In the prior art technology described above, the structure of the vacuum processing apparatus is not much considered. The preliminary vacuum chamber for storing the dummy wafers must have a large capacity, the exclusive conveyor means is necessary for transferring the dummy wafers and thus, the apparatus is complicated in structure.

Dummy wafers used for plasma cleaning are again returned to the preliminary vacuum chamber and are made to stand by. In this instance, reaction products generated during plasma cleaning and residual gas used for plasma cleaning adhere on the used dummy wafers. Thereafter, normal processing for wafers is resumed.

Therefore, the used dummy wafers and unprocessed wafers exist in mixture inside the preliminary vacuum chamber and this state is not desirable from the aspect of contamination of unprocessed wafers.

The present invention provides a vacuum processing apparatus which solves the problems described above, is simple in structure, prevents contamination of unprocessed substrates and accomplishes a high production yield. A vacuum processing apparatus having vacuum processing chambers the insides of which are dry-cleaned after substrates to be treated are processed in vacuum is provided with first storage means for storing substrates to be treated, second storage means for storing dummy substrates, the first and second storage means being disposed in the air, conveyor means for transferring the substrates to be processed between the first storage means and the vacuum processing chambers and for transferring the dummy substrates between the second storage means and the vacuum processing chambers, and control means for controlling the conveyor means so as to transfer the dummy substrates between the second storage means and the vacuum processing chambers before and after dry cleaning of the vacuum processing chambers. A method of operating a vacuum processing apparatus having vacuum processing chambers the insides of which are dry-cleaned after substrates to be processed are processed in vacuum comprises the steps of disposing first storage means for storing the substrates to be processed together with second storage means for storing dummy substrates in the air atmosphere, transferring the substrates to be processed between the first storage means and the vacuum processing chambers and vacuum-processing the substrates to be processed, and transferring the dummy

substrates between the second storage means and the vacuum processing chambers before and after dry-cleaning of the vacuum processing chambers.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a plan view of a dry etching apparatus as an embodiment of a vacuum processing apparatus in accordance with the present invention; and

Fig. 2 is a vertical sectional view taken along line 1 - 1 of Fig. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As substrates to be processed are processed in a vacuum processing apparatus, reaction products adhere to and are deposited in vacuum processing chambers. The reaction products adhering to and deposited in the vacuum processing chambers are removed by disposing dummy wafers inside the vacuum processing chambers and by conducting dry-cleaning. To carry out dry cleaning, the timings of dry cleaning of the vacuum processing chambers are determined and during or after the processing of a predetermined number of substrates to be processed, dummy substrates are conveyed by substrate conveyor means from dummy substrate storage means disposed in the air atmosphere together with processed substrate storage means, and are then disposed inside the vacuum processing chambers. After the dummy substrates are thus disposed, a plasma is generated inside each of the vacuum processing chambers to execute dry-cleaning inside the vacuum processing chamber. After dry-cleaning inside the vacuum processing chambers is completed, the dummy substrates are returned from the vacuum processing chambers to the dummy substrate storage means by the substrate conveyor means. In this manner, a preliminary vacuum chamber and an exclusive transfer mechanism both necessary in prior art techniques become unnecessary,

and the apparatus structure gets simplified. The dummy substrates used for the dry-cleaning and the substrates to be processed do not co-exist inside the same chamber, so that contamination of substrates to be processed due to dust and remaining gas is prevented and a high production yield can be achieved.

Hereinafter, an embodiment of the present invention will be explained with reference to Figs. 1 and 2.

Figs. 1 and 2 show a vacuum processing apparatus of the present invention which is, in this case, a dry-etching apparatus for etching wafers, i.e., substrates to be processed by plasma.

Cassette tables 2a to 2c are disposed in an L-shape in this case in positions such that they can be loaded into and unloaded from the apparatus without changing their positions and postures. In other words, the cassettes 1a to 1c are fixed always in predetermined positions on a substantially horizontal plane, while the cassette tables 2a and 2b are disposed adjacent to and in parallel with each other on one of the sides of the L-shape. The cassette table 2c is disposed on the other side of the L-shape. The cassettes 1a and 1b are for storing unprocessed wafers and for recovering the processed wafers. They can store a plurality (usually 25) of wafers 20 as the substrates to be treated. The cassette 1c in this case is for storing the dummy wafers for effecting dry-cleaning using plasma (hereinafter referred to as "plasma-cleaning") and recovering the dummy wafers after plasma-cleaning. It can store a plurality of (usually twenty-five pieces) dummy wafers 30.

A load lock chamber 5 and unload lock chamber 6 are so disposed as to face the cassette tables 2a

and 2b, and a conveyor 13 is disposed between the cassette tables 2a, 2b and the load lock chamber 5 and the unload lock chamber 6. The load lock chamber 5 is equipped with an evacuating device 3 and a gas introduction device 4, and can load unprocessed wafers in the vacuum apparatus through a gate valve 12a. The unload lock chamber 6 is similarly equipped with the evacuating device 3 and the gas introduction device 4, and can take out processed wafers to the atmosphere through a gate valve 12d. The conveyor 13 is equipped with a robot having X, Y, Z and θ axes, which operates so as to deliver and receive the wafers 20 between the cassettes 1a, 1b and the load lock and unload lock chambers 5 and 6 and the dummy wafers 30 between the cassette 1c and the load lock and unload lock chambers 5 and 6.

The load lock chamber 5 and the unload lock chamber 6 are connected to a transfer chamber 16 through the gate valves 12b and 12c. The transfer chamber 16 is rectangular, in this case, and etching chambers 11a, 11b and 11c are disposed on the three side walls of the transfer chamber 16 through gate valves 15a, 15b and 15c, respectively. A conveyor 14 capable of delivering the wafers 20 or the dummy wafers 30 from the load lock chamber 5 to the etching chambers 11a, 11b, 11c and of delivering them from the chambers 11a, 11b, 11c to the unload lock chamber 6 is disposed inside the transfer chamber 16. The transfer chamber 16 is equipped with an evacuating device 17 capable of independent evacuation.

The etching chambers 11a, 11b, 11c have the same structure and can make the same processing. The explanation will be given on the etching chamber 11b by way of example. The etching chamber 11b has a sample table 8b for placing the wafers 20 thereon, and

a discharge chamber is so provided as to define a discharge portion 7b above the sample table 8b. The etching chamber 11b includes a gas introduction device 10b for introducing a processing gas in the discharge portion 7b and an evacuating device 9b for decreasing the internal pressure of the etching chamber 11b to a predetermined pressure. The etching chamber 11b further includes generation means for generating a microwave and a magnetic field for converting processing gas in the discharge portion 7b to plasma.

A sensor 18 for measuring the intensity of plasma light is disposed at an upper part of the etching chamber. The measured value of the sensor 18 is inputted to a controller 19. The controller 19 compares the measured value from the sensor 18 with a predetermined one and determines the timing of cleaning inside the etching chamber. The controller 19 controls the conveyors 13 and 14 to control the transfer of the dummy wafers 30 between the cassette 1c and the etching chambers 11a to 11c.

In a vacuum processing apparatus having the construction described above, the cassettes 1a, 1b storing unprocessed wafers are first placed onto the cassette tables 2a, 2b by a line transfer robot which operates on the basis of the data sent from a host control apparatus, or by an operator. On the other hand, the cassette 1c storing the dummy wafers is placed on the cassette table 2c. The vacuum processing apparatus executes the wafer processing or plasma cleaning on the basis of recognition by itself of the production data provided on the cassettes 1a to 1c, of the data sent from the host control apparatus, or of the command inputted by an operator.

For instance, the wafers 20 are sequentially loaded in the order from above into the etching

chambers 11a, 11b, 11c by the conveyors 13 and 14, and are etched. The etched wafers are stored in their original positions inside the cassette 1a by the conveyors 14 and 13. In this case, from the start to the end of the operation, without changing the position and posture of the cassettes, the unprocessed wafers are taken out from the cassettes and are returned in their original positions where the wafers have been stored, and are stored there. In this manner, the apparatus can easily cope with automation of the production line, contamination of the wafers due to dust can be reduced and high production efficiency and high production yield can thus be accomplished.

As etching is repeated, the reaction products adhere to and are deposited on the inner wall of the etching chambers 11a to 11c. Therefore, the original state must be recovered by removing the adhering matters by plasma cleaning. The controller 19 judges the timing of this plasma cleaning. In this case, a portion through which the plasma light passes is provided in each of the etching chambers 11a to 11c. The sensor 18 measures the intensity of the plasma light passing through this portion and when the measured value reaches a predetermined one, the start timing of plasma cleaning is judged. Alternatively, the timing of plasma cleaning may be judged by counting the number of wafers processed in each etching chamber by the controller 19 and judging the timing when this value reaches a predetermined value. The actual timing of plasma cleaning that is carried out may be during a processing of a predetermined number of wafers in the cassette 1a or 1b, after the processing of all the wafers 20 in a cassette is completed and before the processing of wafers in the

next cassette.

Plasma cleaning is carried out in the following sequence. In this case, the explanation will be given about a case where the etching chambers 11a to 11c are subjected to plasma cleaning by using three dummy wafers 30 among the dummy wafers 30 (twenty-five dummy wafers are stored in this case) stored in the cassette 1c.

Dummy wafers 30 which are stored in the cassette 1c and are not used yet or can be used because the number of times of use for plasma cleaning is below a predetermined one are drawn by the conveyor 13. At this time, dummy wafers 30 stored in any position in the cassette 1c may be used but in this case, the position numbers of the dummy wafers in the cassette and their number of times of use are stored in the controller 19, and accordingly dummy wafers having smaller numbers of times of use are drawn preferentially. Then, the dummy wafers 30 are loaded in the load lock chamber 5 disposed on the opposite side to the cassette 1a by the conveyor 13 through the gate valve 12a in the same way as the transfer at the time of etching of wafers 20. After the gate valve 12a is closed, the load lock chamber 5 is evacuated to a predetermined pressure by the vacuum exhaust device 3 and then the gate valves 12b and 15a are opened. The dummy wafers 30 are transferred by the conveyor 14 from the load lock chamber 5 to the etching chamber 11a through the transfer chamber 16 and are placed on the sample table 8a. After the gate valve 15a is closed, plasma cleaning is carried out in the etching chamber 11a in which the dummy wafers 30 are disposed, under a predetermined condition.

In the interim, the gate valves 12a, 12b are closed and the pressure of the load lock chamber 5 is

returned to the atmospheric pressure by the gas introduction device 4. Next, the gate valve 12a is opened and the second dummy wafer 30 is loaded in the load lock chamber 5 by the conveyor 13 in the same way as the first dummy wafer 30, and evacuation is effected again by the evacuating device 3 to a predetermined pressure after closing the gate valve 12a. Thereafter, the gate valves 12b and 15b are opened and the second dummy wafer 30 is transferred from the load lock chamber 5 to the etching chamber 11b through the transfer chamber 16 by the conveyor 14. Plasma cleaning is started after the gate valve 15b is closed.

In the interim, the third dummy wafer 30 is transferred into the etching chamber 11c in the same way as the second dummy wafer 30 and plasma cleaning is carried out.

After plasma cleaning is completed in the etching chamber 11a in which the first dummy wafer 20 is placed, the gate valves 15a and 12c are opened. The used dummy wafer 30 is transferred from the etching chamber 11a to the unload lock chamber 6 by the conveyor 14. Then, the gate valve 12c is closed. After the pressure of the unload lock chamber 6 is returned to the atmospheric pressure by the gas introduction device 4, the gate valve 12d is opened. The used dummy wafer 30 transferred to the unload lock chamber 6 is taken out in the air by the conveyor 13 through the gate valve 12d and is returned to its original position in the cassette 1c in which it is stored at the start.

When plasma cleaning of the etching chambers 11b and 11c is completed, the second and third dummy wafers 20 are returned to their original positions in the cassette 1c.

In this way, the used dummy wafers 30 are returned to their original positions in the cassette 1c and the dummy wafers 30 are always stocked in the cassette 1c. When all the dummy wafers 30 in the cassette 1c are used for plasma cleaning or when the numbers of times of use of the wafers 30 reach the predetermined ones after the repetition of use, the dummy wafers 30 are replaced as a whole together with the cassette 1c. The timing of this replacement of the cassette is managed by the controller 19 and the replacement is instructed to the host control apparatus for controlling the line transfer robot or to the operator.

Although the explanation given above deals with the case where the etching chambers 11a to 11c are continuously plasma-cleaned by the use of three dummy wafers 30 among the dummy wafers 30 in the cassette 1c, other processing methods may be employed, as well. For example, the etching chambers 11a to 11c are sequentially plasma-cleaned by the use of one dummy wafer 30. In the case of such plasma cleaning, unprocessed wafers 20 can be etched in etching chambers other than the one subjected to plasma cleaning, and plasma cleaning can thus be carried out without interrupting etching.

If the processing chambers are different, for example, there are an etching chamber, a post-processing chamber and a film-formation chamber, and wafers are sequentially processed while passing through each of these processing chambers, each of the processing chambers can be subjected appropriately to plasma cleaning by sending dummy wafers 30 during the processing of the wafers 20 which are stored in the cassette 1a or 2a and drawn and sent sequentially, by passing merely the dummy wafers 30 through the

processing chambers for which plasma cleaning is not necessary, and by executing plasma cleaning only when the dummy wafers 30 reach the processing chambers which need plasma cleaning.

According to the embodiment described above, the cassette storing the dummy wafers and the cassettes storing the wafers to be processed are disposed together in the air, the dummy wafers are loaded from the cassette into the apparatus by the same conveyor as the conveyor for transferring the wafers, at the time of cleaning, and the used dummy wafers are returned to their original positions in the cassette. In this way, a mechanism for conducting exclusively plasma cleaning need not be provided, and the construction of the apparatus can be simplified. It is not necessary to handle plasma cleaning as a particular processing sequence, but the plasma cleaning can be incorporated in an ordinary etching processing and can be carried out efficiently in a series of operations.

The dummy wafers used for plasma cleaning are returned to their original positions in the cassette placed in the air. Accordingly, the used dummy wafers and the wafers before and after processing do not exist mixedly in the vacuum chamber, so that contamination of wafers due to dust and remaining gas does not occur unlike conventional apparatuses.

The used dummy wafers are returned to their original positions in the cassette and the numbers of times of their use is managed. Accordingly, it is possible to prevent the confusion of the used dummy wafers with the unused dummy wafers and the confusion of the dummy wafers having small numbers of times of use with the dummy wafers having large numbers of times of use. For these reasons, the dummy wafers can

be used effectively without any problem when plasma cleaning is carried out.

Furthermore, in accordance with the present invention, the apparatus can have a plurality of processing chambers and can transfer wafers and dummy wafers by the same conveyor. Since plasma cleaning can be carried out by managing the timing of cleaning of each processing chamber by the controller, the cleaning cycle can be set arbitrarily, dry cleaning can be carried out without interrupting the flow of the processing, the processing can be efficiently made and the productivity can be improved.

As described above, according to the present invention, there are effects that the construction of the apparatus is simple, the substrates to be processed are free from contamination and the production yield is high.